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September 1, 1964

Winnie M. Morgan, M. D.
Report Control Officer
Grants and Research Contracts
Office of Space Science
National Aeronautics and Space Administration
Washington 25, D.C.

Re: Voucher No. 11 for Contract NASr-83

Dear Dr. Morgan:

The following is our progress report for the period April 1 through June 30, 1964.

Monkey Project:

This quarter, twenty-two orbits were run bringing to 147 the number of orbits completed on the project. The orbits were distributed over the senior Nemestrina monkeys as follows: NA-3, 4 orbits; NA-4, 5 orbits; NA-6, 4 orbits; and NA-9, 5 orbits, AND NA-5, 4 ORBITS.

Our goals this quarter with the senior Nemestrina monkeys were (1) to increase the output of the three low-output monkeys, (2) to modify the tests to make them more effective in inducing performance decrements since only one of the two high-output monkeys has shown decrements so far, and (3) to try to stabilize the form of the decrement in the animal (s) showing it.

Some success was achieved with the low output monkeys by testing them more regularly, by giving easier problems to NA-3, and by finding an alternative to shock for punishing failures to respond with NA-9. See Fig. 1 - 3.

The second goal was pursued by attempting to add a vigilance component to the problem. First, the time allowed for response was reduced from 20 seconds to 5 seconds, a minimal time since on problems with three interpolated cues the animal had to make five responses. Inter-trial intervals were increased from 8 seconds to 20 seconds to make continuous attending more difficult. This manipulation did not produce the desired decrement (see Fig. 4 and 5), and it was decided that a separate problem was needed to make an adequate vigilance requirement. This problem consisted of 96 trial sessions in which on each trial a red light appeared in one of three windows. Depression of the lighted window within 2 seconds prevented shock to the animal's thighs and activated the sugar pellet dispenser. Trials were separated by three and ten second intervals, randomly interspersed. Performance on this "red light" problem showed strong individual differences. See Fig. 6. The 96 trial sessions of the red light problem took no longer than the 24 trial sessions of the other two problems, so the addition of this problem doubled the number of trials and the number of sugar pellets available to the animal per hour. The effect of sugar satiation would be a lower overall level of accuracy on the interpolated cue and reversal problems, output on these problems being controlled by the shock. There is no evidence of this effect in NA-4 (Fig. 7), but some suggestion of it in NA-5 (Fig. 8). The sugar pellets are definitely less reinforcing than the shock since neither of these high output monkeys takes all of the pellets he earns in an orbit. NA-5 took 2,709 of 6,487 in orbit 144, and NA-4 took 2,727 of 4,286 in orbit 145. To deal with this disparity, the red light problem will be run without food reinforcement next quarter.

The goal of stabilizing the form of the decrement shown by NA-5 was only partially realized. The animal's accuracy decreased over time on the reversal problem of orbit 131 (Fig. 9), on the interpolated cue problem of orbit 136 (Fig. 8), and on both problems in orbit 144 (Figs. 8 and 10). His output fell off over time in both problems of orbit 140 (Fig. 11). There was no decrement on the interpolated cue problem of orbit 131 or the reversal problem of orbit 136.

Output decrements in both reversal and interpolated cue problems were obtained from NA-6 in orbit 137 (Fig. 4) and from NA-9 in orbit 141 (Fig. 3).

Training of the younger Nemestrina has continued. NA-10 and NA-11 have begun their second reversal with color cues, NA-12 his first. NA-13 was traded for another monkey because of epileptic EEG patterns. His successor, NA-15, has been chaired, but not yet trained or given a headplug.

A 4' x 4' x 6' exercise cage with ladder, trapeze and two perches was completed this quarter. It is used by two or three animals at a time for 3 to 4 day periods.

Testing of the monkeys was interrupted twice this quarter by the death of two monkeys, NA-4 and NA-9; and illness of 3 monkeys at one time and 4 at another from an acute gastric dilatation. Because of the peculiar circumstances that only animals in chairs were affected, testing was temporarily discontinued pending pathological and toxicological investigations. The pathologist suggested toxemia or toxicosis, and an acute "toxicological feeding" of sugar pellets was given to a non-project monkey. The results were negative, so general changes were made in the feeding, watering, and security of the animals and testing was resumed with no recurrence of the problem to date. Four new monkeys have been ordered.

Chimpanzee Project:

Two new chimpanzees arrived this quarter. Although large, Patricia is very docile and readily learned to push the windows of the test panel. She has begun training on a discrimination problem and will be chaired early next quarter. Oscar was found to have a possible chondrosarcoma and will be shipped back to Holloman. No replacement is planned. The other two chimpanzees regressed when the difficulty of their reversal problems was increased too soon, and have spent most of the quarter gaining back their facility with discrimination problems. They are now ready for a second try at the reversals and for the tick-tack-toe problem as soon as the panel for it is finished.

Human Project:

Ten human orbits have been completed this quarter, three using the "simultaneous reversal" and "duplicating the sequence" problems described in the January report, and seven using modifications of a problem developed by the Houston Manned Spacecraft Center. In the first three orbits it was established that the reversal problem was too easy and that the other problem required retention of so much information that it could be handled only with some coding system. How well performance held up over time was a function of the various coding systems devised by different subjects. This variability due to different codings could have been eliminated by shortening the sequence to be remembered and duplicated so that coding was not necessary, and by keeping the subject too busy to permit learning of a code.

However, information was made available at this time of the type of problem being used at Houston, and it was decided to try their task in the interests of coordination of effort. The test chamber and panel of push windows from the earlier problems were used. On each trial of the new task an instruction listing three colors was given to the subject via a tape recorder. Following the instruction, colors appeared in three of the windows and the subject rapidly pushed the windows according to the sequence of colors given in the instructions. The colors appeared in different windows each trial and sometimes, in the Henry Ford Hospital version of the task, one of the colors requested was not in the display. In this case the subject pushed a special window designating "not here" at the time in the sequence when he would have pushed a window of the absent color. The Houston task was thus modified to make it more difficult and counteract discrepancies in the motivational levels of research project personnel and potential astronauts. As in Houston, orbits lasted at least two hours with 20 minutes of testing followed by 10 minute rest periods. Errors were indicated to the subject by mild shock to his left hand.

In the first orbit the limit on the time in which the subject could make his responses was 3 seconds, the middle value used by Houston. Performance was very accurate throughout, so in five subsequent orbits the minimal Houston limit of 1-1/2 seconds was used. Table I shows the data from these five orbits. The overall level of performance was lower than with 3 seconds, and there were two decrements, 26 percent in orbit 8H, and 13 percent in orbit 5H. Nevertheless, the stable performance in orbits 6H and 7H suggested that the test was not yet adequate. The disparity between the Ford Hospital data and that reported by Houston (Frazier) may be motivational. Only one of the Ford subjects reported or demonstrated pre-orbit anxiety over the quality of his performance, and this subject's performance was much worse than the others. See orbit 9H in Table I.

To get a higher proportion of subjects showing decrements, the task was modified to make it more perceptual and less a matter of response time. The three colors were displayed in windows which were farther apart, the time of presentation was reduced to 300 msec., so that the windows were blank again by the time that responses were being made, and the time allowed for the three responses was increased to 2 seconds. Other changes made at this time were elimination of the rest period and flashing of a large "X" in a central window after errors rather than shocking the subject's hand. It was time-consuming to set shock levels for each subject, and subjects reported no effects of the shock other than information. This second task was described as much more tiring than the first, but the data shows some learning over and above any decremental effects of the changes in procedure. See Table II.

The next step planned is to complicate the task by requiring subjects to maintain more than one set as to the designations of the windows. Each window will have a permanent number or symbol designation, and a temporary color designation and the three instructions each trial will be a combination of numbers or symbols and colors.

TABLE I

Percent correct responses of five human S's on first Ford version of the Houston problem with 1-1/2 sec. time limit on responses, and the modification that on one-fourth of the trials a blank window must be pushed in place of a requested color that was not presented.

	Sessions						
Orbits	1	2	3	4	5	6	7
5H (project staff)	74	81	73.5	67.8			
6H (project staff)	69.2	74	72.6	74.7	73		
7H (project staff)	70.8	72.1	67.6	76.6	72.8	78.2	
8H (non-project staff)	49.6	60	53.6	48.2	41.4	42.6	34.1
9H (project staff)	6.7						

TABLE II

Comparison of percent correct responses on the Houston problem in successive orbits by the same subject. The second orbit differed from the first in that presentations of colors were shorter and response time longer, lighted windows were farther apart, rest periods were eliminated, and shock after errors was replaced by a visual cue.

	Sessions						
Orbits	1	2	3	4	5	6	7
6H	69.2	74	72.6	74.7	73		
10H	71.4	75.4	75	78.2	75.9	80	

EEG and Computer Reports:

Four of the orbits included the magnetic taping and computer processing of the EEG. Two of these orbits showed decrement in behavior and two did not.

The major EEG effort of this quarter was towards a more exact analysis of the results of the zero crossing program.

There is a theorem in statistics (Fieller's Theorem) that establishes the limits within which a true mean ration between two populations must lie, given pairs of samples from these two populations.

Using the amount of activity in a given bandwidth (e. g. theta frequency) in the rest period and the subsequent performance period as the sample populations, we applied this theorem to our zero crossings results. We used first a set of samples from the first few hours of the orbit, and then repeated the procedure for the hours when the performance decrement was greatest. The mathematical model of this is as follows:

let X_1 = theta (rest period) (hours 1-20)

let Y_1 = theta (performance period) (hours 1-20)

let $\frac{X_1}{Y_1} = \alpha_1$ then PROBABILITY $\left\{ \underset{\text{lower limit}}{\alpha_1} \ngtr \alpha_{1_\mu} \ngtr \underset{\text{upper limit}}{\alpha_1} \right\} = .99$

let X_2 = theta (rest period) (hours 32-42)

let Y_2 = theta (performance period) (hours 32-42)

then $\frac{X_2}{Y_2} = \alpha_2$

If the particular bandwidth carries no information; that is, it is part of noise and is distributed uniformly in time in all cases then: $\alpha = 1/1 = 1.0$

If $\alpha \neq 1.0$ then the signal is not noise but reflects a function of the source of the signal, and if $\alpha_1 \neq \alpha_2$ it is proof of an effect of the testing conditions on the source of the signal since processing conditions are held rigidly identical in both cases.

The computer program for this theorem has been written and tested. It has been applied to Orbit 126 in which the monkey showed a decrement in performance.

In this case $\alpha_{1_\theta} = 1.0$ but $\alpha_{2_\theta} < 1.0$

and $\alpha_{1_\delta} = 1.0$ but $\alpha_{2_\delta} > 1.0$

therefore α_{2_θ} and α_{2_δ} seemed to be complementary to one another.

During the next quarter we will apply this theorem to the results we have from the orbits that have had computer processing of the EEG.

Biotelemetry Report:

During this quarter we made up miniature printed wiring boards for our transmitters, subcarrier oscillators and for a pre-amplifier[1]. These wiring boards provide a very considerable improvement over previous methods of assembly of our electronic circuits. Improved are the uniformity of construction, ease of testing, ease of servicing and the neatness of assembly. With conventional soldering techniques a limit is soon reached beyond which further size reduction is not possible, with the wiring boards as fabricated by the method described below this limit is extended considerably.

Photofabrication:

The method of fabrication (photofabrication [2]) is new to us and a number of experiments were performed to establish optimum working conditions which will be described in some detail.

1. Preparation of the master artwork.

The preparation of the master artwork is started after a circuit and the components for it are decided upon. Preliminary work in the form of hand drawn sketches is used to arrive at a component layout with a near optimum in component density. The master artwork is the final plan of component interconnections. The plan may be drawn larger than actual size (typically by a factor 8) as photographic reduction may be used with this method to produce a film negative at actual size (transparency). Extremely small and still very accurate wiring boards can thus be made. Commercially available pre-cut adhesive printed circuit drafting aids were used [3]. As base material we tried first opaque paper sheet with front illumination and later translucent polyester film sheet with back illumination.

2. The preparation of transparencies.

A Leica camera with a 35 mm. Kodak High Contrast Film and a Speedgraphic camera with a 5 x 4 inches Kodak Ortho Type 3 Film were tried to obtain negative transparencies of the master artwork. The exposed films were processed in a high contrast developer. (Kodak D-19 developer).

3. Copper-clad laminates with a coat of photosensitive resist, and its exposure and processing.

Preliminary experiments were performed with purchased photoresist coated copper-clad phenolic sheets [4]. In the later phase, use was made of Kodak Ortho Resist [5] which was applied to General Electric Textolite copper-clad laminates. Exposure times for a given spectral distribution of the light source and spectral sensitivity of the film were determined by experiment. An ASA number was assigned to the film as a result of these experiments. Experience was gained regarding the need for dust-free enclosure for spraying and drying during the photoresist coating process, and during the development of the exposed photoresist coated copper-clad laminate. Contamination and surface scratching are factors which dictate careful handling of material. The need for additional equipment was assessed at this stage.

4. Removal of the unexposed portion of copper-clad by chemical etching.

The final step in the preparation of the printed wiring board is the etching of the exposed and developed board. Experimentally, we determined the best etchant, its molarity, the degree of permissible contamination of the etchant during the process of etching, the optimal ambient temperature and the need for physical agitation. The etchant vapours are poisonous and a safe working method had to be established.

As a result of these experiments we concluded:

1. Translucent material such as polyester film with back illumination results in better resolution and is to be preferred to opaque paper with front illumination.

2. A single camera (such as the Speed-graphic) for 5 x 4 inch precut film will suffice for all the work which we expect to be involved in.

3. Kodak Ortho Type 3 Film gives very good contrast.

4. For our purposes, trichloroethelene is a more suitable developer than the one recommended by Kodak for the Kodak Ortho Resist.

5. Dust-free enclosure must be provided during the application of photo-resist and during drying, while storing and during the period of drying after developing.

6. The optimum molarity of the etchant (ferric chloride) used in our experiments is 2.2 to 2.5 M.

7. To minimize etching time the contamination of the etchant must be kept to a minimum. Discarding of etchant after use is recommended.

8. To protect those working with the chemicals a good ventilation of the working area was found to be essential.

Application:

The time required to perform the various steps outlined above from the preparation of the master artwork to the finished product is about two days. Approximately 8 wiring boards can presently be fabricated at one time, but this number could be increased if required. The above work is justified by the fact that much longer time delays would be incurred if the wiring boards had to be ordered from an outside company.

The physical size of our preamplifiers is 1-3/4 x 1-1/4 x 3/4 inches. This is three times as small as the size given by Kado[1]. Cord-wood packaging technique was used. The gain was 10,000 - 20,000 and the common mode rejection was 1000 at 10 c/s and 3600 at 50 c/s. The noise referred to the input is 2 micro volt RMS over a frequency band from 1 to 80 c/s and with a 15 K Ohm source impedance.

Printed wiring boards for the subcarrier oscillators and the transmitter [6] have been made and these units are presently being assembled. The method of construction given in reference 6 is now to be abandonned, (page 7).

Future Plans:

1. Assembly of 4 more preamplifiers using printed wiring boards in order to complete the four channel multiplexing FM-FM telemetry system as described in reference 6. This will serve to gain experience with the performance of such systems.

2. Further work on preamplifiers (see reference 6, page 7). We have succeeded in setting up equipment to measure the noise performance of transistors. This arrangement will be used to test small package transistors and integrated circuit devices (when they become available at reasonable prices). This should lead to the reduction of the physical size of our telemetry units.

In this report, you will note we have begun to place more emphasis on the following:

1. Human performance and the EEG correlates.

2. More sophisticated data processing of the EEG (Fieller's Theorem).

3. Production of our own miniature preamplifiers using our own printed circuits.

Hoping you will find this progress report adequate.

Yours sincerely,

Lorne D. Proctor, M. D.
Chairman - Department of
Neurology and Psychiatry

LDP/B
Enclosures

REFERENCES

1. The electrical circuit of this preamplifier was taken from:

   "A Transistorized Preamplifier for Field Study of EEG" by R.T. Kado and W.R. Adey.. Digest of the 1961 International Conference on Medical Electronics.

2. Techniques of Microphotography, Kodak Publication No P-52 and Kodak Photosensitive Resists for Industry, Kodak Publication No P-7; Eastman Kodak Company, Rochester, N.Y. 14650.

3. W.H. Brady Company, 727 W. Glendale Avenue, Milwaukee, Wisconsin, 53209 and By-Buk, 4314 W. Pico Blvd., Los Angeles, California 90019.

4. Etched Circuit Lab Kit Kepro Tyoe L-505A-G.

5. Ortho Resist Spray Kit Eastman Kodak Company, Graphic Arts Division Rochester, New York 14650.

6. Henry Ford Hospital Voucher No 10 dated April 15, 1964 for NASA Contract NASr-83.

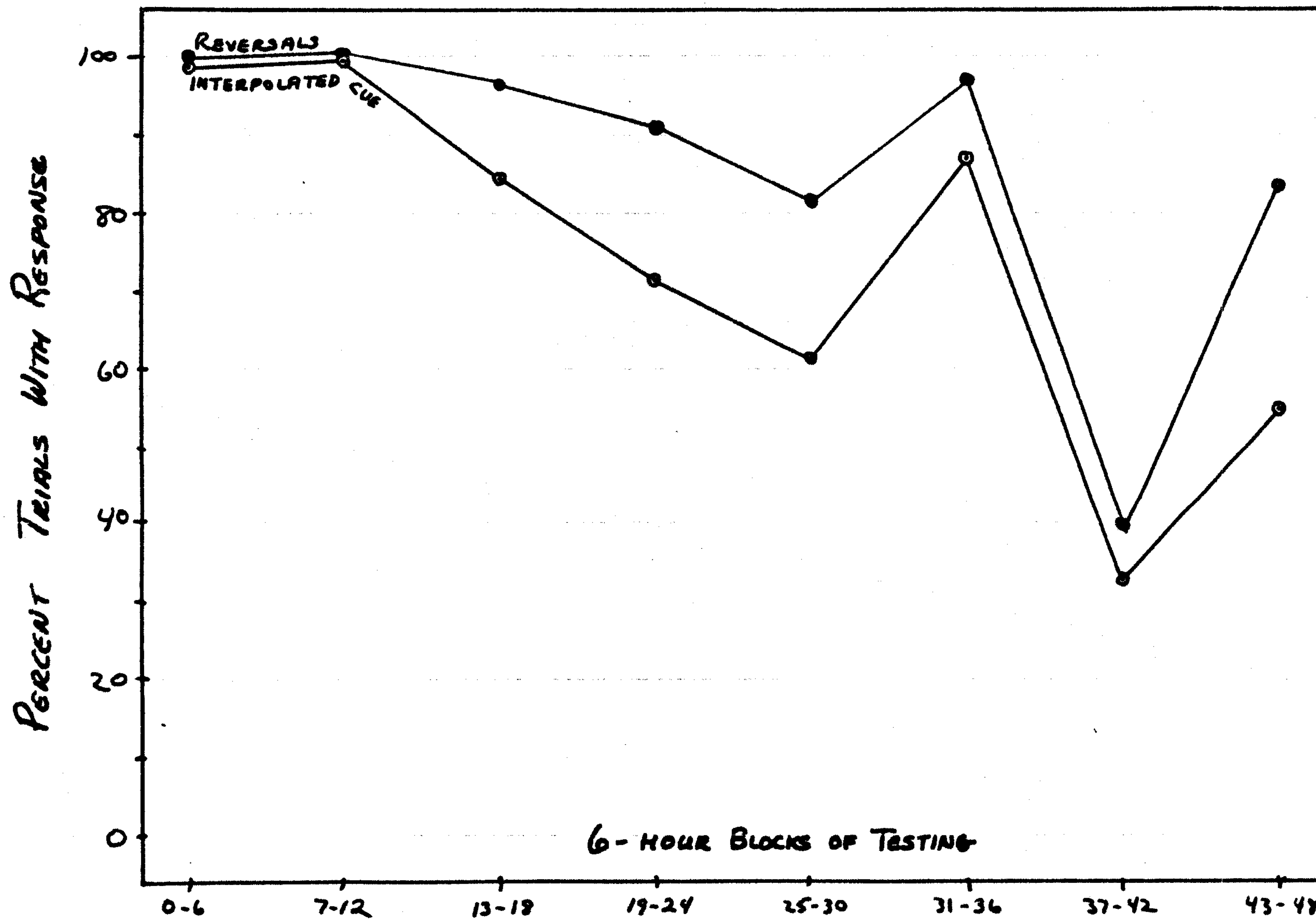

Figure 1. Output of NA-6 on interpolated cue and reversal problems of Orbit 137.

June 30, 1964

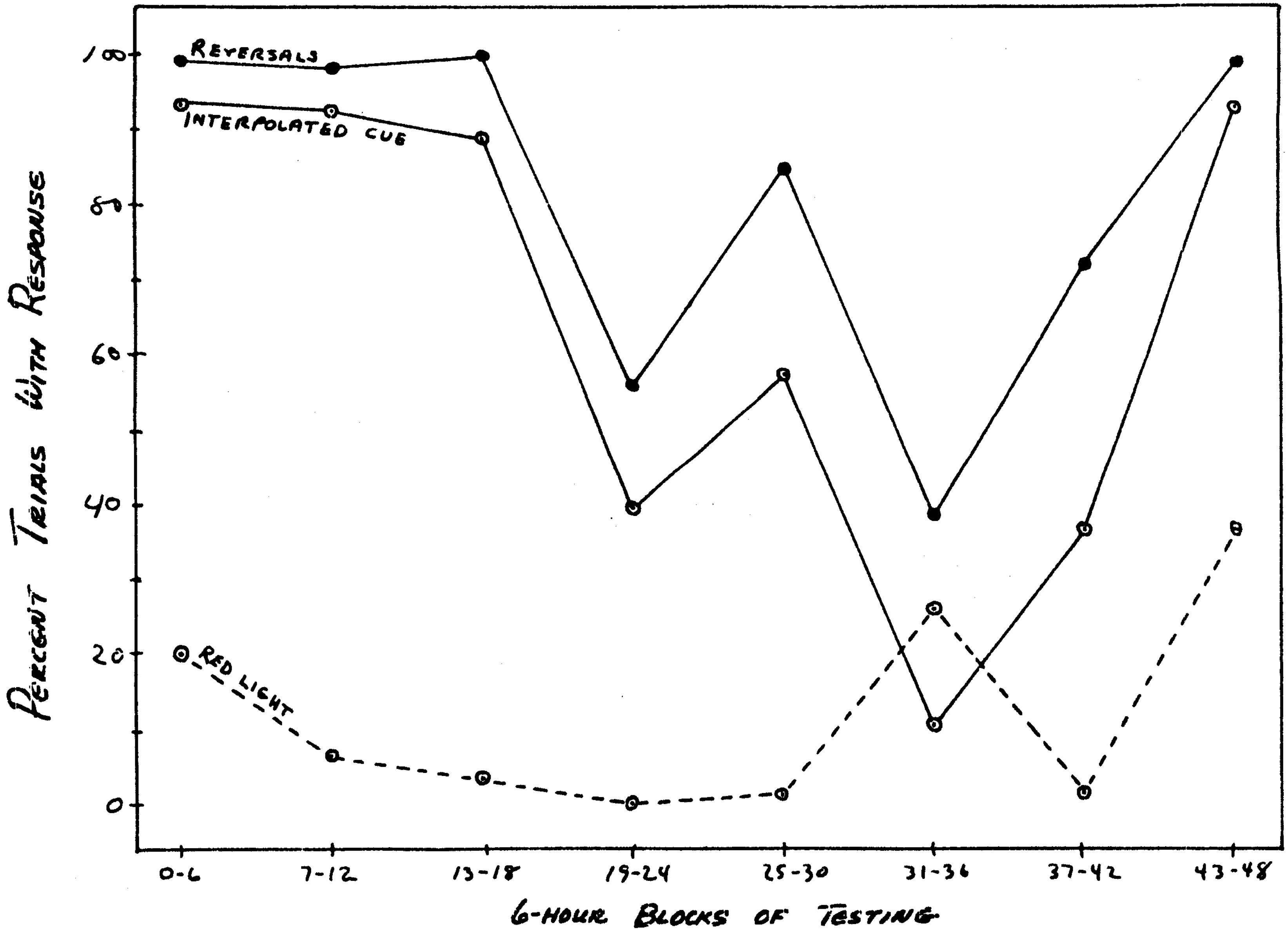

FIGURE 2. OUTPUT OF NA-3 ON REVERSAL, INTERPOLATED CUE, AND RED LIGHT PROBLEMS OF ORBIT 143.

JUNE 30, 1964

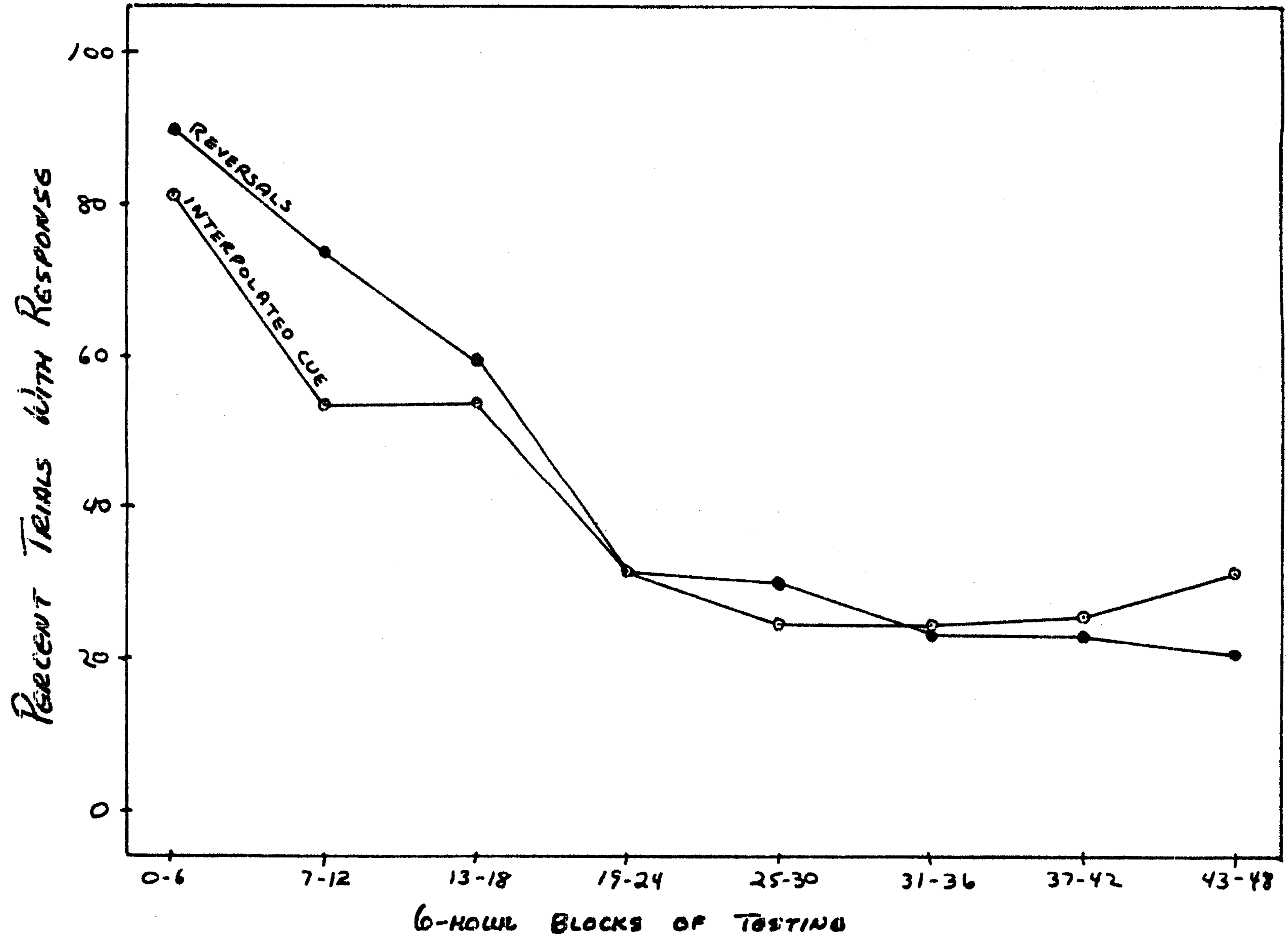

Figure 3. Output of NA-9 on interpolated cue and reversal problems of Orbit 141.

June 30, 1964

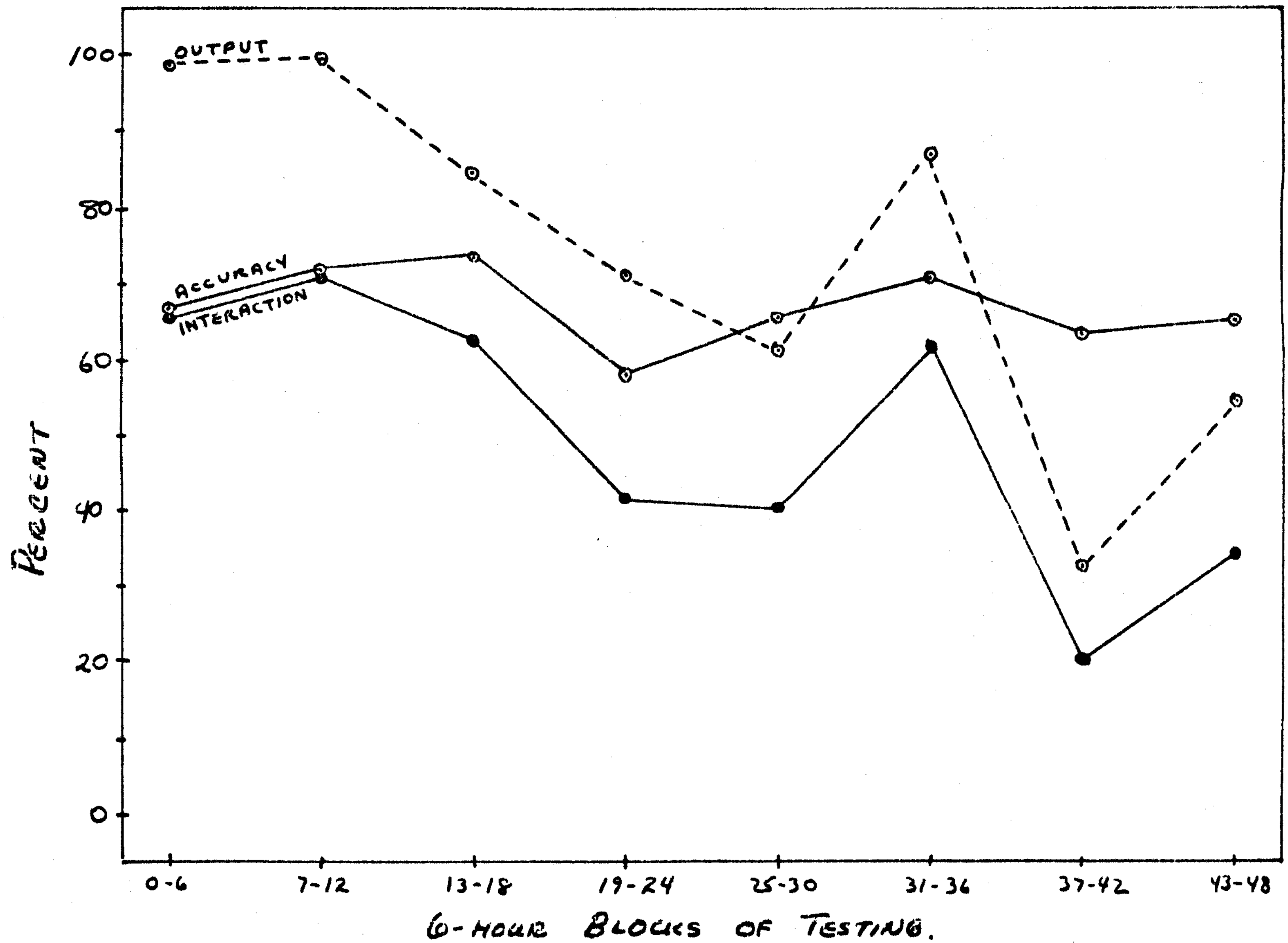

FIGURE 4. PERFORMANCE OF #A-6 ON INTERPOLATED CUE PROBLEMS OF ORBIT 1.37 IN WHICH THE DURATION (MAXIMUM) OF TRIALS WAS 20 SEC., INTER-TRIAL INTERVALS 8 SEC.

JUNE 29 1964

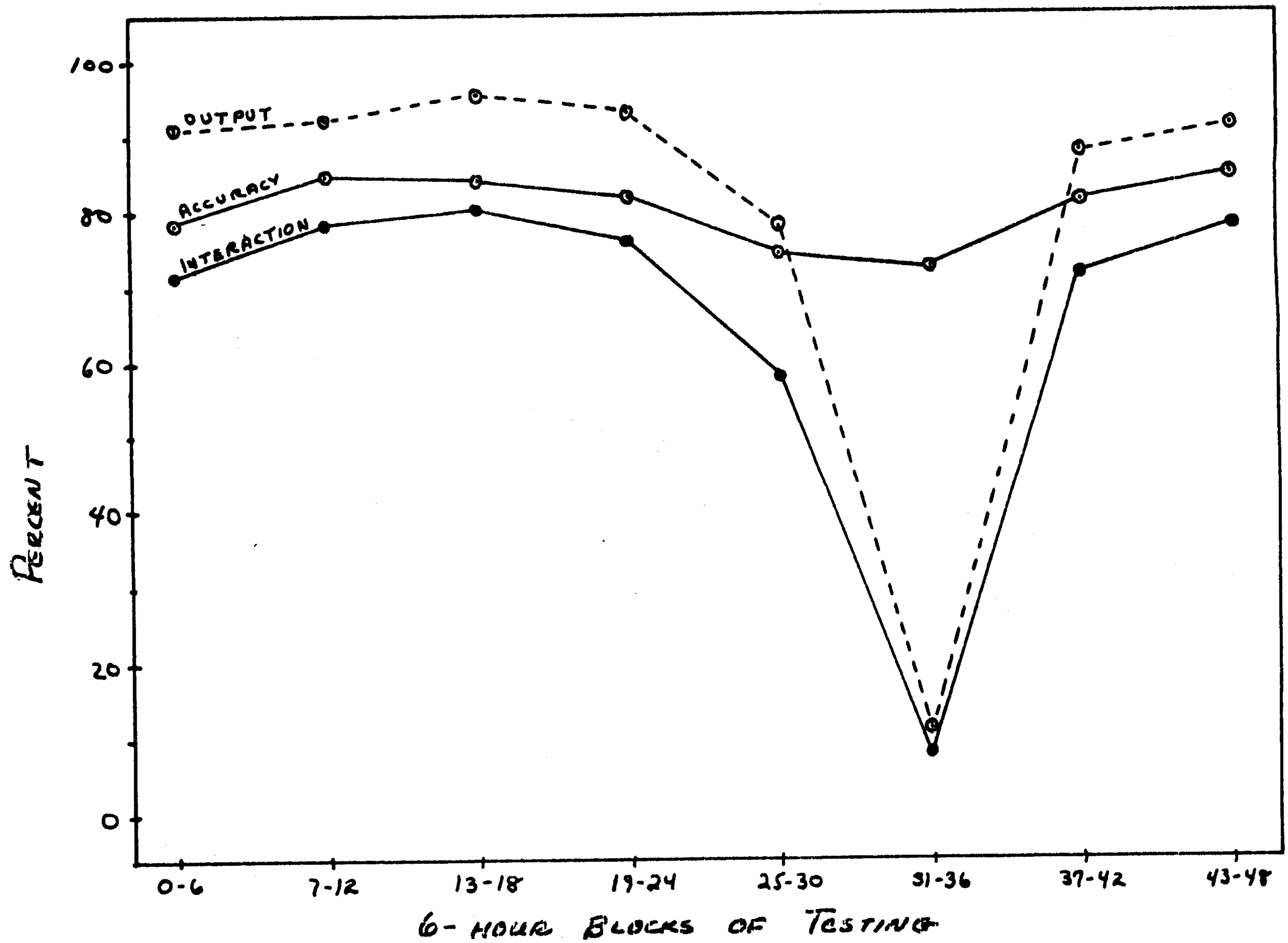

FIGURE 5. PERFORMANCE OF NA-6 ON INTERPOLATED CUE PROBLEMS OF ORBIT 147 IN WHICH THE MAXIMUM DURATION OF TRIALS WAS 5 SEC., OF INTER-TRIAL INTERVALS 20 SEC.

JUNE 30, 1964

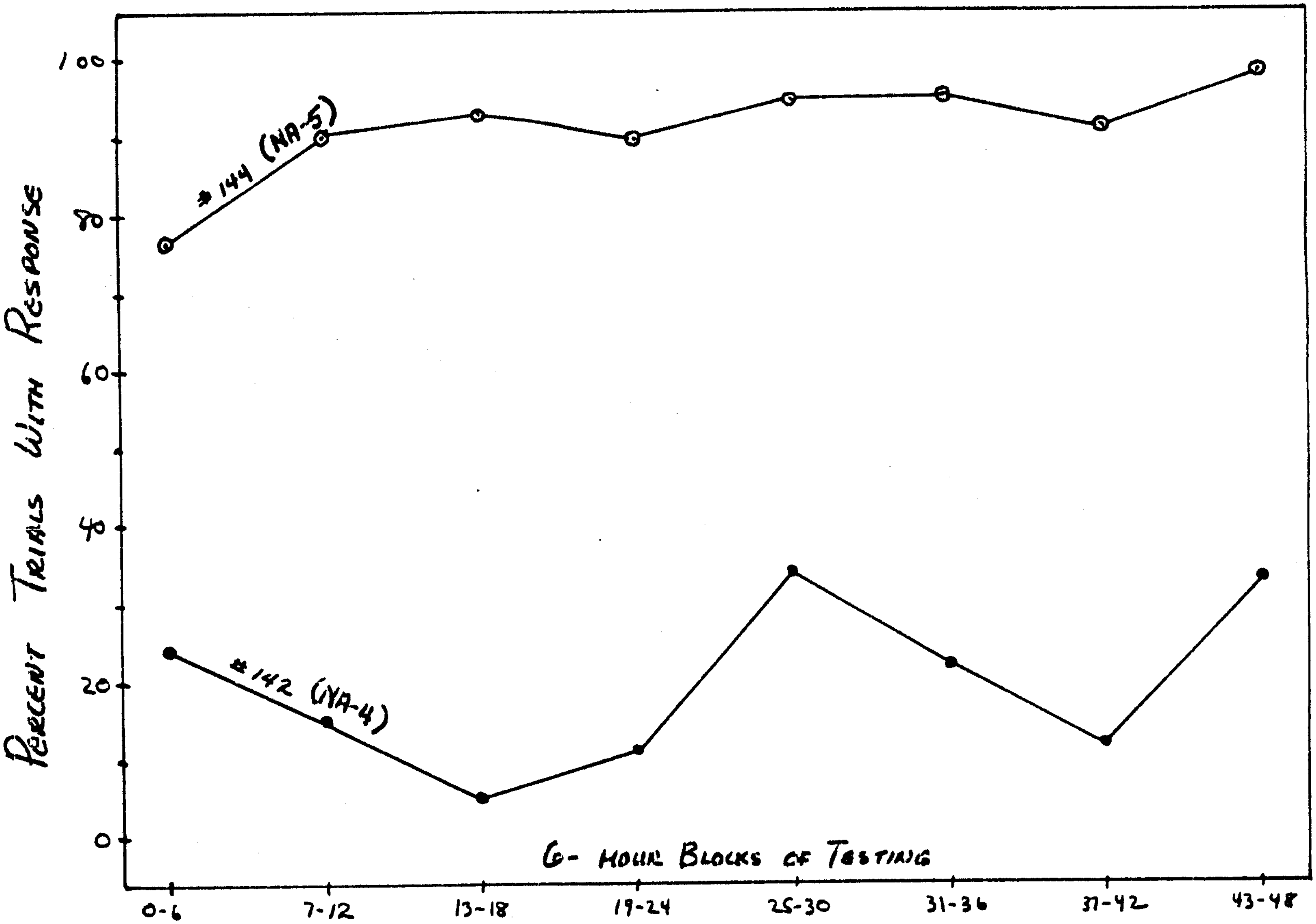

FIGURE 6. COMPARISON OF PERFORMANCES OF NA-4 AND NA-5 ON THE RED LIGHT PROBLEM.

JUNE 30, 1964

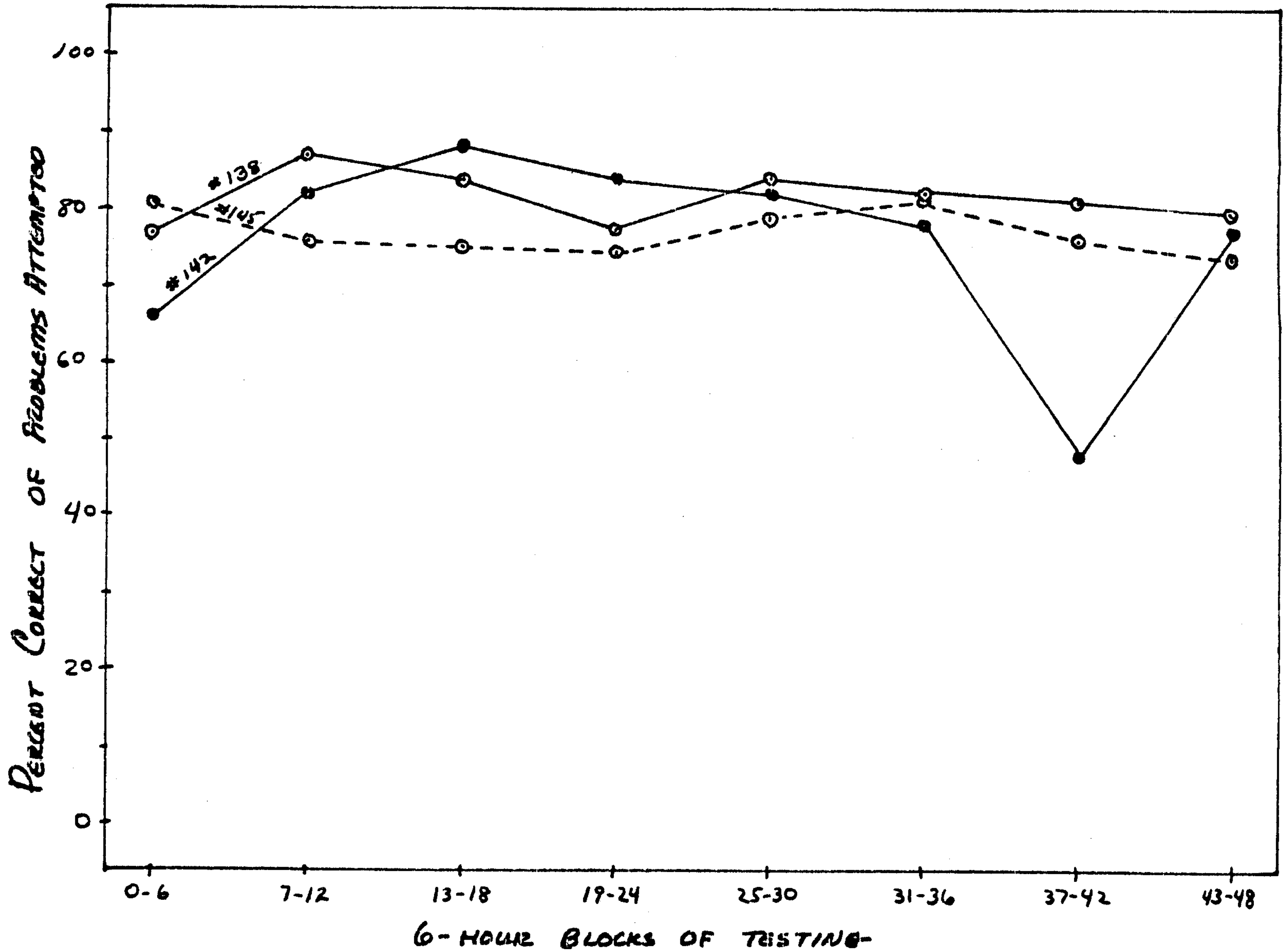

FIGURE 7. ACCURACY OF AA-4 ON INTERPOLATED CUE PROBLEMS OF ORBIT 138 IN WHICH THERE WAS NO RED LIGHT PROBLEM, ORBIT 142 IN WHICH EVERY THIRD SESSION WAS A 48-TRIAL RED LIGHT PROBLEM, AND ORBIT 145 IN WHICH EVERY THIRD SESSION WAS A 96-TRIAL RED LIGHT PROBLEM.

JUNE 30, 1964

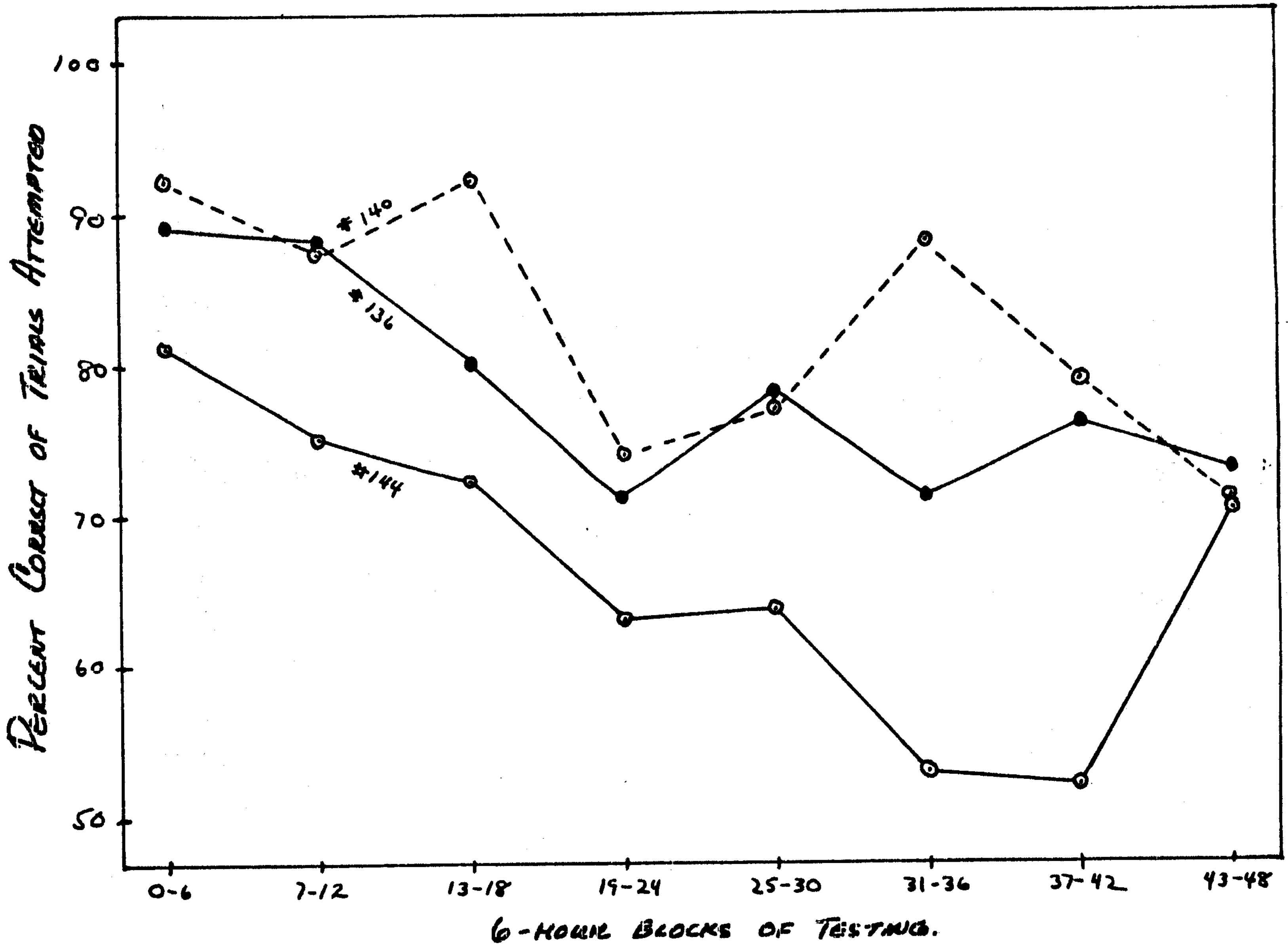

Figure 8. Accuracy of HA-5 on interpolated cue problems of orbits 136 and 140 in which there was no red light problem and orbit 144 in which every third session was a 96-trial red light problem.

June 30, 1964

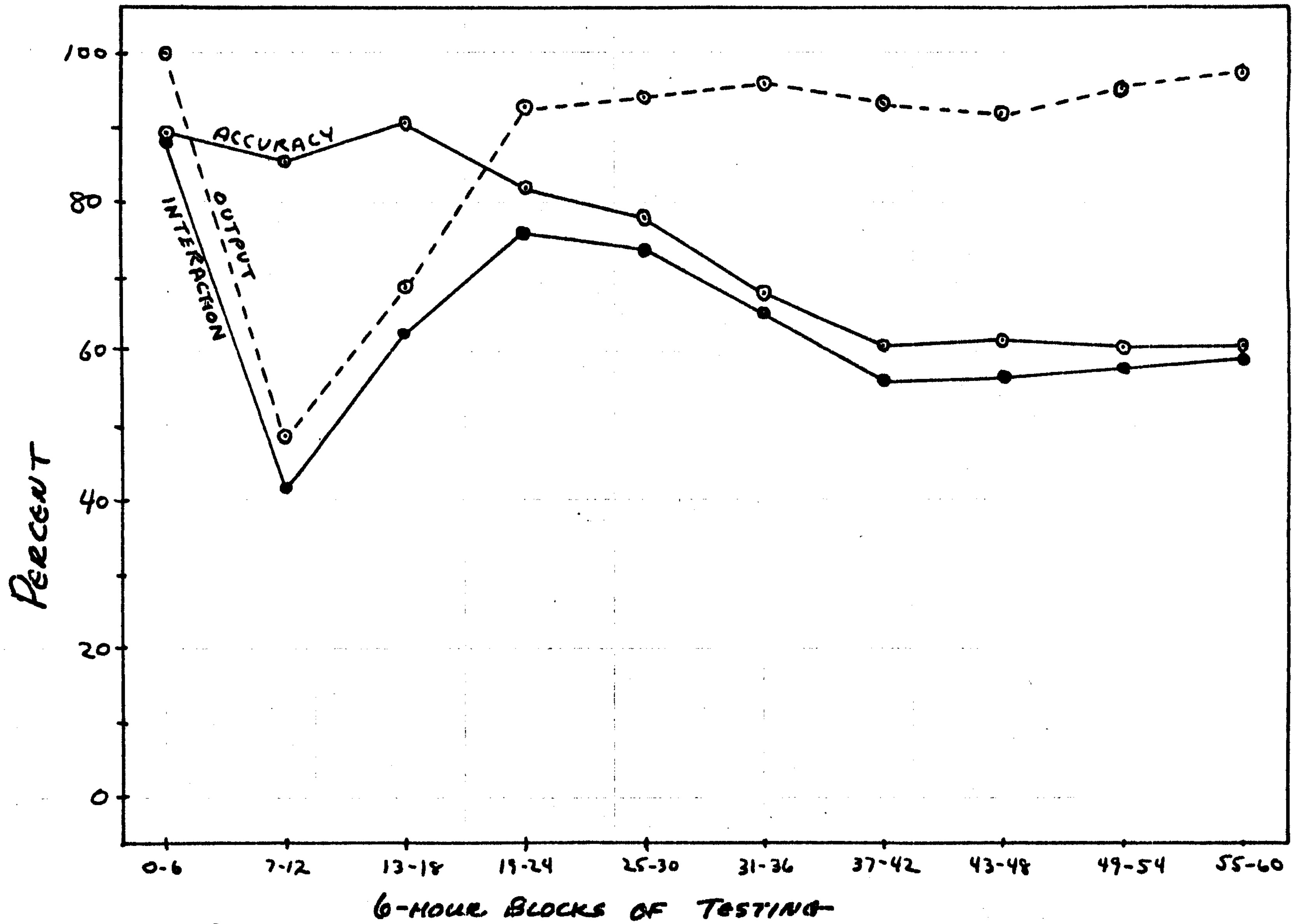

FIGURE 9. PERFORMANCE OF #A-5 ON THE REVERSAL PROBLEMS OF ORBIT 131.

JUNE 29, 1964

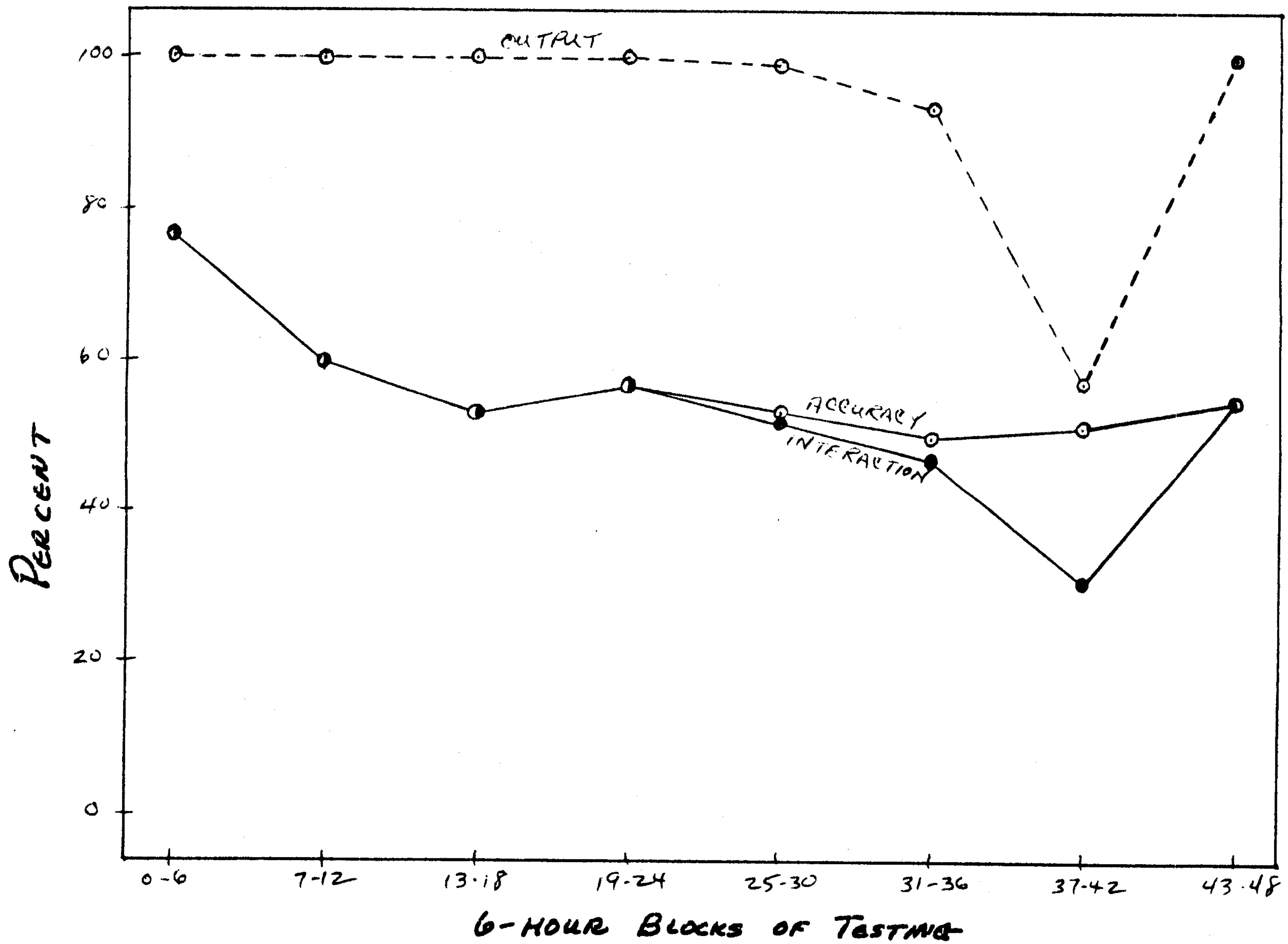

FIGURE 10. PERFORMANCE OF NA-5 ON REVERSAL PROBLEMS OF ORBIT 144.

JUNE 29 1964

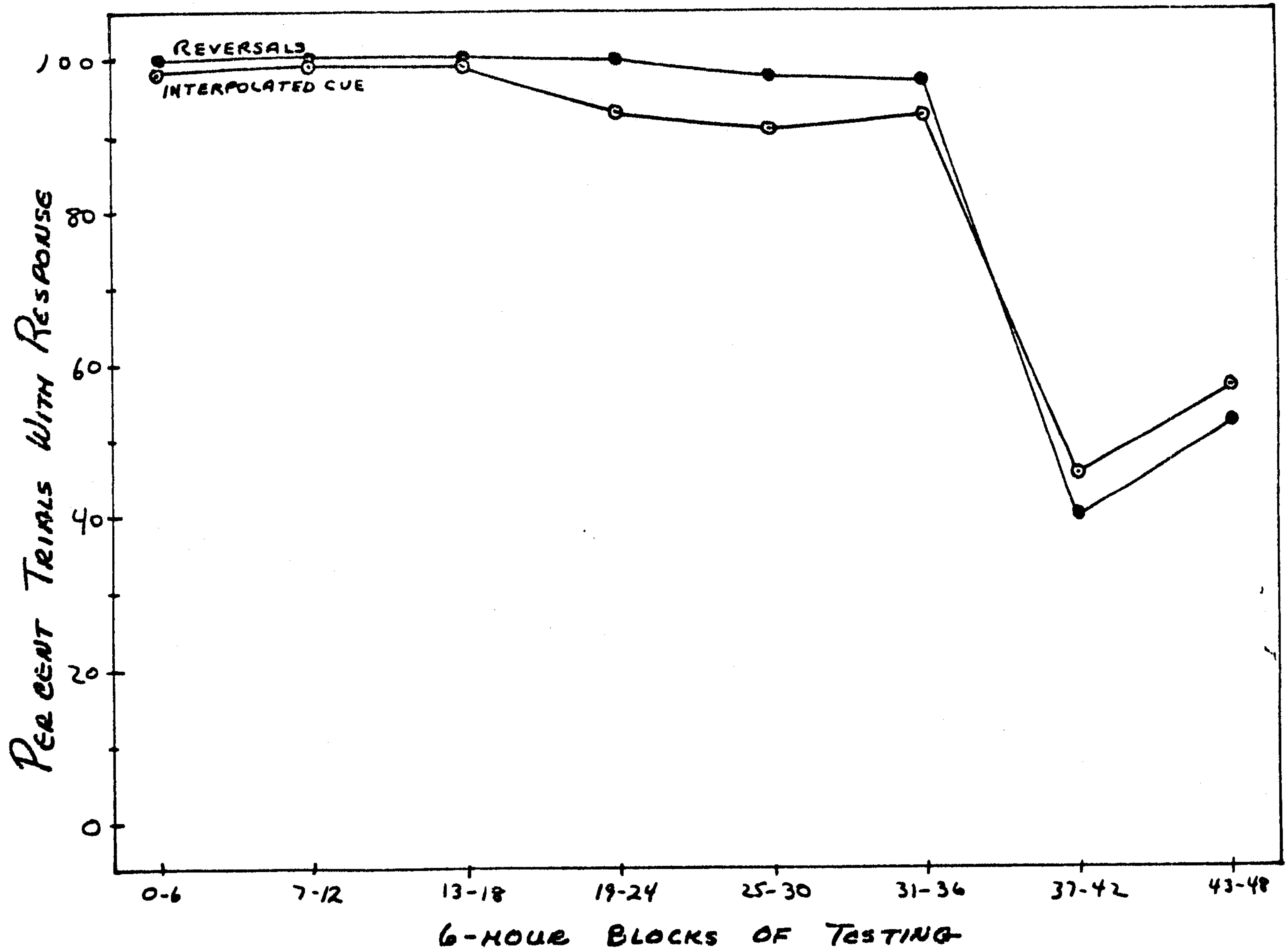

FIGURE 11. OUTPUT OF NA-5 ON REVERSAL AND INTERPOLATED CUE PROBLEMS OF ORBIT 140.

JUNE 30, 1964